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CO₂ LASER FREQUENCY MULTIPLICATION

REPORT FOR DECEMBER 1991

CONTRACT NO. 00014-91-C-2279

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A Lumonics 203 TEA discharge laser was refurbished for use as an amplifier. After conditioning, only two out of the three 40 cm gain modules would operate with greater than 90% reliability. The third module would arc prematurely on 50% of shots, so it was not used in our initial amplification experiments. Using an input mode-locked pulse train (TEM₀₀, 9.55 μm , 3 μsec duration, 2 nsec pulses spaced by 40 nsec) a gain of 4 was obtained at an input energy of 40 mJ. The input Gaussian spot radius parameter was 0.5 cm, so that an output energy density of 0.4 J cm⁻² was achieved in the unfocussed exit beam. Further increase in energy density could be achieved in principle by beam expansion before amplification, followed by reduction to the 1 cm aperture of the AgGaSe₂ doubling crystal.

By appropriate timing of the oscillator and amplifier pulses, the envelope of the mode-locked pulse train could be improved. Without amplification, the "spike" to "tail" ratio ranged between 4 and 8, depending on the intensity of line injection, but after amplification of only the tail portion of the pulse, with a gain of 4, the "spike" to "tail" ratio was approximately in the range of 2:1. This improvement will allow a meaningful study of frequency doubling with trains of 100 pulses in duration, contrasted with the 10 pulse duration of a typical spike.

The reproducibility of the envelope of the mode-locked pulse train was improved greatly through the introduction of an intra-cavity monitor of the injected intensity. This intensity peaks when the cavity length is an exact multiple of $\lambda/2$, where λ is the injected wavelength. We tuned the cavity length manually, if needed, prior to a shot and thereby achieved 100% successful line injection with a stable envelope. Prior to this development, as a back-up approach to line selection, a 9.5 μm blazed grating had been ordered which is due for delivery in the near future and will be used to obtain envelopes in which the "spike" dominates the "tail" by a ratio of 10:1 or greater.

A 35 mm long x 10 mm x 10 mm type I AgGaSe₂ crystal was received from Cleveland Crystals in mid December. It has been mounted on a

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temperature-controlled stage with rotation and translation. A MgF_2 window was bought to separate $9.55 \mu\text{m}$ from $4.775 \mu\text{m}$ by differential absorption. Preliminary frequency doubling at relatively low intensities ($< 1 \text{ MW cm}^{-2}$) has shown that the crystal is optically perfect throughout its length, as evidenced by the clearly defined $(\sin \theta/\theta)^2$ pattern of second harmonic power versus crystal angle, with a half-width to the first zero of only 0.2° (internal). The same curve taken at two temperatures (30°C and 58°C) shows almost no change at all in the phase-matching angle ($< 0.01^\circ$ internal) indicating that the temperature coefficient of the index difference is less than 3×10^{-7} per $^\circ\text{C}$. This is even smaller than the low value of 1.1×10^{-6} obtained for frequency doubling of $10.6 \mu\text{m}$ by Barnes et al in 1979, obtained by comparing between 100°K and 298°K .

In the coming month we plan to study second harmonic generation with short and long pulses trains at increasing fluences. We shall look at the optical quality of the second harmonic beam. A second type I crystal will be purchased in order to generate the third harmonic of $9.55 \mu\text{m}$ at $3.18 \mu\text{m}$, by mixing with $4.77 \mu\text{m}$. (Type II material is still unavailable).



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6 January 1992

Naval Research Laboratory
Attn: Mr. Barry Feldman, Code: 6540
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Washington, DC 20375-5001

Subject: Contract No. N00014-91-C-2279
Monthly Progress Report - December 1991

Dear Mr. Feldman:

In accordance with the 91-C-2279 contract, Textron Defense Systems (TDS) hereby forwards one copy of the subject report. Additional distribution has been made to the offices set forth below, per Enclosure 1 of the DD Form 1423.

Very truly yours,

Textron Defense Systems



C. Thomas Christiano
Manager of Contracts

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Enclosure

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